Original Article

Effects of Tai Chi Training on Improving Physical Function in Patients With Coronary Heart Diseases

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An attempt was made in the present study to examine the effects of Tai Chi training on improving physical function in patients with coronary heart diseases. Participants of this study were 30 male ($n = 18$) and female ($n = 12$) patients who had gone through the hospital stay (Phase I) and cardiac rehabilitation program (Phase II) and planned to get involved in a home-based or a long-term exercise program (Phase III) after a heart operation or a cardiac event. Informed consent form and permission from the physicians of the patients as well as from the medical center were obtained before the beginning of the study. An equal number of male ($n = 9$) and female ($n = 6$) patients were randomly assigned to an experimental group and a control group. The study lasted 12 weeks and consisted of a pretest, an intervention phase, and a posttest. On the pretest, each participant was required to take physical function tests on leg strength, flexibility, agility, balance and cardiovascular endurance. During the intervention phase, a modified Tai Chi training program was offered by a well-trained Tai Chi instructor to the experimental group under the supervision of an experienced cardiologist at a local medical center and a researcher at a college in the northeast region of the United States. Participants in the control group, however, were not involved in the Tai Chi training program during the same time period. All participants were encouraged to continue their standard cardiac rehabilitation activities and routine care procedures. The intervention phase lasted 12 weeks and included two 1-hour Tai Chi classes per week. During the period of intervention, the physical and health conditions of each participant were closely and regularly checked and monitored by a cardiologist. At the end of the 12-week intervention, a posttest with similar testing procedures to those of the pretest was administered to all participants. A 2×2 (group $\times$ test) MANOVA with repeated measures on the test was used to examine differences in physical function variables between the two groups. Follow-up tests were conducted on any significant main or interaction effects. The results of the study revealed a significant group $\times$ test interaction ($p < 0.001$). Follow-up analyses indicated that while no group differences in physical function variables existed between the two groups on the pretest, the experimental group was found to have significantly ($p < 0.05$) better performance on the physical function tests than the control group. The findings of the present study suggest that Tai Chi training enhances physical function in patients with coronary heart diseases and is an effective cardiac rehabilitation exercise alternative to the traditional ones. [*J Exerc Sci Fit* • Vol 8 • No 2 • 78–84 • 2010]

Keywords: cardiac rehabilitation, coronary heart diseases, Tai Chi training

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Introduction

Heart disease is the number one cause of death in the United States (American Heart Association 2008). In 2005, a total of 654,091 people died of heart disease (Centers for Disease Control and Prevention 2008). According to the American Heart Association (2008), about 1 million Americans suffered from acute myocardial infarction in 2005. Such a high cardiac event occurrence and death rate can be attributed, in part, to the lack of physical activity in American lives (Powell & Blair 1994). Over the past 10 years, the government and various professional organizations have made great efforts to promote healthy lifestyles and take preventative measures to deal with this serious health issue. A number of research studies have been conducted to investigate the effects of different exercise and training programs on patients with coronary heart diseases and to develop strategies to prevent heart attack and cardiovascular events (e.g. Ayabe et al. 2008; Farsidfar et al. 2008; Mueller et al. 2007; Scholz et al. 2007; Barnard et al. 2000; King et al. 2000; Oka et al. 2000; Speed & Shapiro 2000; Hare et al. 1999; Petrella 1999). The general agreement in the research findings of previous studies is that both group-centered and home-based fitness training programs have positive effects on physiological function and quality of life in patients with heart disease.

In addition, the effects of various fitness training programs offered after a cardiovascular event and/or heart surgery on improving functional capacity of patients have been examined by some researchers (e.g. Ayabe et al. 2008; Farsidfar et al. 2008; Mueller et al. 2007; Scholz et al. 2007; Barnard et al. 2000; King et al. 2000; Oka et al. 2000; Speed & Shapiro 2000; Hare et al. 1999; Petrella 1999). Buckley et al. (1999) reported that treadmill exercise was more metabolically efficient than rowing ergometry for male patients soon after myocardial infarction. Vescovi and Fernhall (2000) claimed that resistance training improved the physiological and psychological parameters of cardiac patients who had a cardiac event and thus enhanced cardiac rehabilitation. According to Dylewicz et al. (2000), short-term endurance training was beneficial to glucose metabolism during rehabilitation after coronary bypass surgery. In a more recent study, Adams et al. (2008) found that exercise training in supervised cardiac rehabilitation programs resulted in significant improvement in exercise capacity, measures of chronotropic dynamics, and prognostic risk scores in patients with heart disease. The researchers concluded that the exercise training programs lead to a decrease in predicted mortality. Pozehl et al. (2008) demonstrated that exercise training has beneficial effects on symptoms of fatigue and dyspnea in heart failure patients.

In an attempt to examine the effects of upper-body progressive resistance training on body strength and household physical activity performance in women attending cardiac rehabilitation, Coke et al. (2008) randomly assigned women patients into either a usual care aerobic exercise or a moderate-intensity progressive resistance training group for a 10-week exercise training program. Women patients in the resistance training group demonstrated a significant increase in muscle strength and household activities scale scores compared to those in the usual care aerobic exercise group. Concluding from the reports of the previous studies, fitness programs have a positive impact on the functional capacity of patients who have suffered a cardiac event. More research studies, however, are needed to investigate the effects of fitness programs on the physical function of patients who have completed the hospital stay (Phase I) and outpatient cardiac rehabilitation program at the hospital (Phase II) after the cardiac event, and are ready to start home-based activities and a long-term exercise program (Phase III). Participating in an organized and a home-based fitness training program during Phase III would be an important part of long-term intervention and preventative measure for patients after a cardiac event (Ades 2001; Haskell et al. 1994). In addition, more attention should be directed to adopting alternative fitness training programs during the outpatient cardiac rehabilitation phase and the home-based activities phase.

Tai Chi exercise is known as an alternative approach to physical fitness and a low-impact fitness exercise which consists of slow, continuous and graceful body movements. Tai Chi exercise is an ideal mind-body exercise for people of different ages and with different physical and health conditions (Reid 1988). Such an exercise has been found to be effective in helping participants reduce stress, improve body balance and movement control, strengthen cardiovascular function, and increase self-confidence (see Wang et al. 2000 for a review). Wolf et al. (1996) reported that moderate Tai Chi training is beneficial to reducing frailty and falls in older persons. Such a finding was further supported by Wolfson et al. (1996), who found that participants demonstrated significant improvement in maintaining balance gains after practicing Tai Chi movements for 26 weeks. Lan et al. (1996) reported that participants exhibited an increase in trunk flexibility after

participating in Tai Chi exercise. In a later study, Lan et al. (1998) found that participants improved their aerobic capacity and leg strength after engaging in Tai Chi exercise for a year. Similarly, Ross et al. (1999) found that Tai Chi practitioners demonstrated improvements in balance, sway and range of motion. Wolf et al. (1996) further claimed that Tai Chi exercise can slow down the loss of upper body strength. According to Yan (1995), Tai Chi exercise resulted in improvements in the smoothness of arm movement of the participants. More recently, researchers have revealed that Tai Chi exercise/training program is beneficial for improving function and quality of life indicators in elderly people with osteoarthritis (Hartman et al. 2000), decreasing systolic blood pressure and reducing induced stress in older people (Shibata 2001), and providing such a training program to nursing home populations is an economically favorable strategy and a practically feasible intervention (Wilson & Datta 2001). Given its characteristics and positive effects on the cognitive, cardiovascular and musculoskeletal systems, Tai Chi exercise is assumed to be a desirable alternative to the traditional fitness training protocol for patients who are involved in Phase II and III cardiac rehabilitation programs after a cardiac event. To date, however, no study has been conducted to investigate the effects of Tai Chi exercise and training on improving physical function in patients who have had a cardiac event and have been involved in those two phases of cardiac rehabilitation programs. The present study was designed to examine such effects and to explore the possibility of offering an effective and enjoyable exercise alternative to traditional exercise approaches to such patients.

Methods

Participants

Participants of this study were 30 male ($n = 18$) and female ($n = 12$) patients with coronary heart diseases at a local medical center in the northeast region of the United States. All participants had gone through the hospital stay (Phase I) and cardiac rehabilitation program (Phase II) after heart surgery or a cardiac event and planned to get involved in a home-based or a long-term exercise program (Phase III). The participants were fully informed of the procedures, benefits and risks involved in the study. Informed consent form and permission from the physician of each patient as well as from the medical center were obtained before the beginning of the study.

Testing instruments and apparatus

The effects of Tai Chi exercise on physical function was examined by measuring leg strength, leg flexibility, stationary balance, agility, and aerobic endurance of the participants because these physical fitness components are important for good posture, normal gait patterns and numerous mobility tasks such as climbing stairs, walking, shopping, getting in and out of a bathtub or car, and getting up to attend to something in the kitchen. In the present study, leg strength was measured using the chair stand test (Rikli & Jones 2001), which requires the participant to perform full stands from a seated position with arms folded across his/her chest. The number of full stands that can be completed in 30 seconds was recorded. Leg flexibility indicates the range of movement in the knee and was measured in this study using the chair sit-and-reach test (Rikli & Jones 2001), which involves using the hands to reach toward the toes from a sitting position on the edge of the chair with one leg bent and the other leg straight. The number of inches between the extended fingers and the tip of the toe of the straight leg was recorded. Balance is known as the maintenance of equilibrium when stationary or while moving. Stationary balance was evaluated in the current investigation by using the one-leg stand test (Hartman et al. 2000), and the balance score is determined by the total time standing on one leg. Dynamic balance, on the other hand, was measured in the present study using the 8-foot-and-go test (Rikli & Jones 2001), which requires the participant to get up from a seated position, walk 8 feet, turn, and return to the seated position within the shortest period of time (in seconds). Aerobic endurance represents the ability of the cardiovascular and respiratory systems to supply fuel and oxygen to the muscles to allow sustained exercise. In the current study, aerobic endurance was measured using the 2-minute step test (Rikli & Jones 2001), which requires the participant to perform full steps in 2 minutes, raising each knee to a point midway between the patella (kneecap) and iliac crest (top hip bone). The number of times the right knee reaches the required height in 2 minutes was recorded as the score.

Procedures

Participants were randomly assigned to either an experimental group or a control group with an equal number of male ($n = 9$) and female ($n = 6$) participants in each group. The experiment lasted 12 weeks and consisted of a pretest, an intervention phase, and a posttest. On the pretest, all participants were required to take physical

function tests. During the intervention phase, participants in the experimental group were asked to attend two 1-hour Tai Chi activity classes per week offered by a well-trained Tai Chi instructor. Each Tai Chi class included 5 minutes of warm-up exercises, a 40–45-minute session of physical performance of 12-form Tai Chi exercise routine, and 5 minutes of cool-down activities. The control group did not participate in any Tai Chi classes during the intervention phase, but were contacted by the study coordinator to discuss issues related to their cardiac and health condition. All participants were encouraged to continue their standard cardiac rehabilitation activities and routine care procedures. At the end of the 12-week intervention phase, all participants were asked to take a posttest with procedures similar to those used on the pretest.

Participants in the Tai Chi exercise group were required to attend at least 80% of the Tai Chi classes in order to be considered as part of the intervention group. Anyone who missed two consecutive classes was asked to make up the classes and encouraged to stay with the group. All Tai Chi participants met the minimum attendance criterion with 10 participants having perfect attendance. Participants in the control group were asked to keep their normal cardiac rehabilitation routine and to take a pre- and posttest on physical functions.

Statistical analysis

A 2 × 2 (group × test) MANOVA with repeated measures on the test was employed to determine group differences in the performance of the physical function tests. Follow-up analyses were conducted to examine any significant main or interaction effect. All statistical analyses were conducted with SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). The level of significance for the present study was set at 0.05. Post-experimental interviews were also conducted to explore the thoughts and experiences of the participants who participated in the Tai Chi exercise classes as an alternative training program during Phases II and III after a cardiovascular event.

Results

The results of the 2 × 2 (group × test) factorial analysis revealed a significant main effect for the test [Wilks' $\lambda = 0.190$, $F(1, 28) = 20.55$, $p < 0.001$], and a significant group × test interaction effect [Wilks' $\lambda = 0.155$, $F(1, 28) = 16.07$, $p < 0.001$]. Follow-up analyses indicated that while no significant differences were found in all five physical function measures on the pretest (Figure 1), participants in the Tai Chi exercise group had a significantly ($p < 0.05$) higher performance score (17.31 ± 3.66 times) than their control group counterparts (13.93 ± 4.59 times) on the chair stand (leg strength) test. Furthermore, Tai Chi participants demonstrated significantly ($p < 0.05$) longer time (45.63 ± 5.60 seconds) than those in the control group (16.64 ± 5.71 seconds) on the one-leg stand (balance) test, and significantly ($p < 0.05$) faster time (6.44 ± 1.02 seconds) than control participants (9.12 ± 1.63 seconds) on the 8-foot-and-go (agility) test. With regard to performance on the chair sit-and-reach (flexibility) test, participants in the Tai Chi exercise group had a significantly ($p < 0.05$) higher performance score (11.47 ± 2.55 inches) than their control group counterparts (9.68 ± 2.34 inches). Tai Chi participants also demonstrated a significantly ($p < 0.05$) higher number of steps (133.94 ± 42.08) than the control participants (99.14 ± 26.09) on the 2-minute step test. The mean performance scores of the two groups on the posttest of the physical function measures are depicted in Figures 2 and 3, respectively. The summary of descriptive statistics on the pre- and posttest for both groups and follow-up analyses on significant main and interaction effects are shown in Tables 1 and 2, respectively. The results of the post-experimental interviews revealed that 93% of Tai Chi participants enjoyed the Tai Chi exercise classes and thought that Tai Chi exercise should be included in the cardiac rehabilitation program. Moreover, 87% of the Tai Chi participants expressed their interest in continuing their participation in an organized Tai Chi training program in the future.

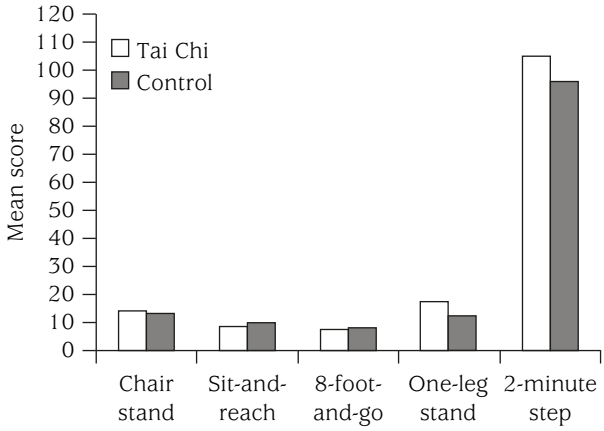

Fig. 1 Mean pretest performance scores of the two groups for the five physical function measures.

Discussion

In the present study, an attempt was made to examine the effects of Tai Chi exercise and training on improving physical function in patients who had a cardiac event and who had been involved in the first two phases of a cardiac rehabilitation program. The results of the present study revealed that participants in the Tai Chi exercise group demonstrated better physical functional performance on leg strength, flexibility, agility, balance and cardiovascular endurance than those in the control group after 12 weeks of Tai Chi training. The findings of this study are consistent with those of previous studies in which fitness exercises were found to be effective in improving the physiological and functional capacity of patients with cardiac diseases during the cardiac rehabilitation phase (e.g. Ayabe et al. 2008;

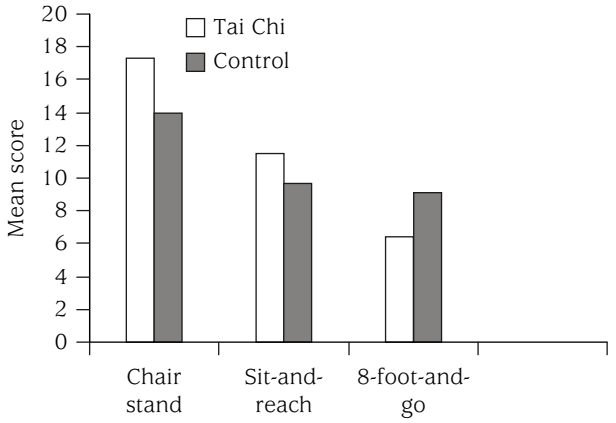

Fig. 2 Mean posttest performance scores of the two groups on three physical function measures.

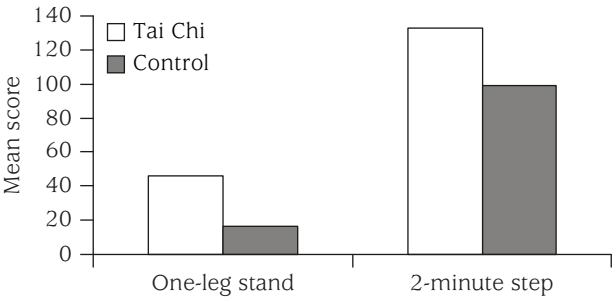

Fig. 3 Mean posttest performance scores of the two groups on two physical function measures.

Table 1. Descriptive statistics on the pre- and posttest for both the Tai Chi exercise and control groups*

Functional measure	Tai Chi group ($n = 15$)	Control group ($n = 15$)
Chair stand		
Pretest	13.94 ± 2.59 times	13.14 ± 4.83 times
Posttest	17.31 ± 3.66 times	13.93 ± 4.59 times
Sit-and-reach		
Pretest	8.38 ± 2.16 inches	9.71 ± 1.70 inches
Posttest	11.47 ± 2.55 inches	9.68 ± 2.34 inches
2-minute step		
Pretest	105.43 ± 44.28 steps	96.43 ± 28.20 steps
Posttest	133.94 ± 42.08 steps	99.14 ± 26.09 steps
8-foot-and-go		
Pretest	7.32 ± 1.98 s	8.07 ± 2.03 s
Posttest	6.44 ± 1.02 s	9.12 ± 1.63 s
One-leg stand		
Pretest	17.37 ± 2.02 s	12.32 ± 1.88 s
Posttest	45.63 ± 5.60 s	16.64 ± 5.71 s

*Data presented as mean ± standard deviation.

Table 2. Summary of follow-up analyses and results on the significant main and interaction effects

Variable	Mean		Mean diff.	t	p
	Tai Chi	Control			
Pretest					
Chair stand	13.94	13.14	0.80	0.57	0.572
Sit-and-reach	8.38	9.71	1.33	−1.87	0.072
2-minute step	105.43	96.43	9.00	0.65	0.519
8-foot-and-go	7.32	8.07	0.75	1.02	0.315
One-leg stand	17.37	12.32	5.05	0.67	0.507
Posttest					
Chair stand	17.31	13.93	3.38	2.24	0.033*
Sit-and-reach	11.47	9.68	1.79	2.25	0.013*
2-minute step	133.94	99.14	34.80	2.65	0.032*
8-foot-and-go	6.44	9.12	2.68	−4.17	< 0.001*
One-leg stand	45.63	16.64	28.99	2.32	0.028*

*$p < 0.05$.

Farsidfar et al. 2008; Mueller et al. 2007; Scholz et al. 2007; Barnard et al. 2000; King et al. 2000; Oka et al. 2000; Speed & Shapiro 2000; Hare et al. 1999; Petrella 1999). These findings suggest that a 12-week Tai Chi exercise program is effective in improving physical function in patients with coronary heart disease.

Among the abovementioned improvements in physical function measures in patients with coronary heart disease as a result of Tai Chi training, the enhancing effect of Tai Chi exercise on balance and agility is worthy of further discussion. The results of the present study reveal that participants in the experimental group demonstrated better performance on the balance test than those in the control group. This finding is in line with those of previous studies in which participants without heart disease were used (e.g. Hartman et al. 2000; Hong et al. 2000; Lin et al. 2000; Ross et al. 1999; Wolf et al. 1996; Wolfson et al. 1996; Tse & Bailey 1992), and provides further evidence for the beneficial effect of Tai Chi exercise on body balance in participants with coronary heart disease. Clearly, Tai Chi exercise is an effective approach to improving body balance in people with different physical conditions and limitations.

The results of the present study also indicate that Tai Chi participants outperformed their counterparts in the control group on the agility test. Such a finding provides initial evidence that Tai Chi exercise may be effective in improving an individual's ability to move and change body direction quickly. Tai Chi exercise involves a combination of frequent weight shifting, spatial orientations, and change in body movement directions (Reid 1988). Previous researchers (e.g. Hong et al. 2000; Lin et al. 2000; Ross et al. 1999; Wolf et al. 1996; Wolfson et al. 1996; Tse & Bailey 1992) have demonstrated that regular Tai Chi exercise leads to improvement in postural stability, functional mobility and balance control. It is possible that the 12-week Tai Chi training in the present study contributed to improvements in dynamic balance and body control of the participants and thus resulted in better agility performance in comparison to that of the control participants. Further studies are needed to examine the enhancing effect of Tai Chi exercise on the agility performance of participants of different ages and with different physical conditions.

Post-experimental interview results of the present study revealed that the majority of the Tai Chi participants enjoyed their experience of the 12-week Tai Chi training and expressed their interest in continuing with Tai Chi exercise as part of their long-term routine cardiac rehabilitation program. Such a finding along with the beneficial effects of Tai Chi training on improving physical function highlights the growing need of providing inclusive, diverse cardiac rehabilitation programs and services for patients with cardiac diseases. Given its positive effects on the physical and mental function variables of the participants as well as its minimum requirement and cost on equipment and space, Tai Chi exercise, as an exercise alternative to traditional fitness exercises, should be included in the traditional cardiac rehabilitation program to benefit those patients with cardiac events who are involved in either a group-centered or home-based fitness training program. It is proposed that integrating traditional and alternative fitness exercises is a feasible and effective approach to strengthening cardiac rehabilitation and home care programs for patients who are involved in Phase II and III cardiac rehabilitation after a cardiac event.

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